
Fish Entrainment Control at Ballard Locks in 2002

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In 2002, we conducted several fish passage investigations at the Ballard Locks: assessment of fish passage over spillway flumes; evaluation of relative fish guidance efficiency at the flumes; estimation of fish entrainment through the large lock filling culverts; and evaluation of strobe lights for reducing fish entrainment into the filling culverts. The flume passage study occurred from 19 April through 11 July and entailed observers stationed on the spillway walkway visually counting out-migrant fish passing the flume outfalls. We estimate that just over a million fish passed the flumes in 2002, the majority passing from 11-26 May. Overall, about 3 fish were passed for every 100 m³ of water. On a per-flume basis, the medium-sized Flume 5C appeared to pass fewer fish per water volume than did the other flumes. A related study by B. Pfeifer (Parametrix) was designed to assess relative fish guidance efficiency (RFGE) of the flumes. The definition of RFGE is (number of flume passed fish / (sum of flume passed and culvert entrained fish)) x 100%. Based on a limited data set, preliminary results suggest that 90-152 aggregate volume cfs is sufficient to achieve high values (>95%) of RFGE.

Passage of fish into the large lock culvert system (entrainment) is considered harmful to fish due to the potential for fish to contact the culvert walls and sharp-edged barnacles that line a large portion of the culvert system. We used split-beam hydroacoustics to estimate the number of fish that were entrained into the large lock culverts from 3 May to 18 July. We sampled a total of 716 fill events (639 upper lock fills and 77 full lock fills) and estimated that a total of 6,671 fish were entrained. The run timing pattern of entrained fish was similar to what was observed at the flumes. Hourly estimates indicate that entrainment occurred primarily during the day, but nighttime entrainment was not trivial. Vertical distributions of entrained fish indicate that at night, fish are distributed deeper than during the day.

During the annual large lock pumpout in November of 2001, we mounted 36 strobe light heads around the perimeter and in front of the two culvert entrances. From 3 May-14 June, 2002 we evaluated the use of strobe lights for reducing fish entrainment into the large lock filling culverts during daylight hours. Based on 95 paired light-on / light-off treatments, strobe lights were shown to significantly reduce fish entrainment (two-tailed paired t-test results: $P < 0.0001$). An estimated 1,427 fish were entrained during lights-off treatments and 350 fish were entrained during lights-on treatments, a reduction of 75%. Effectiveness of strobe lights for entrainment reduction was also supported by t-tests conducted on individual range strata in front of the culvert entrances: one-meter range strata from the floor to 4 m above the floor indicated significant reduction in number of entrained fish during lights-on treatments as compared to lights-off treatments ($P < 0.0001$ for all 4 range strata).